STATE OF CALIFORNIA—BUSINESS, TRANSPORTATION AND HOUSING AGENCY

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METHOD FOR DETERMINATION OF ASPHALT BINDER PROPERTIES USING A DYNAMIC SHEAR RHEOMETER

CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read **"SAFETY AND HEALTH"** in Part 4 of this method. It is the responsibility of the user of this method to consult and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed.

A. OVERVIEW

This test method covers the use of a dynamic shear rheometer for determining the complex modulus and phase angle at different temperatures and frequencies. These values are then used either directly or indirectly for calculating parameters that have been correlated with the contribution of an asphalt binder to pavement performance at low, medium and high temperatures. The test method is essentially AASHTO Designation: TP5 with additional data collection and alternate sample geometry. The procedures are applicable to neat and modified asphalts incorporating either polymers or ground tire rubber.

B. APPARATUS

The dynamic shear rheometer test system specified in Section 6 of AASHTO Designation: TP5 is used with the following additions: (1) Section 6.1.1 - An alternate sample geometry shall consist of a sample cup (diameter of 42 mm and a depth of 8 mm) and a stepped disc (serrated surface with a diameter of 8 mm and a smooth surface with a diameter of 25 mm) and (2) Section 6.1.2.1 - The test temperature range is from -20 to 85°C.

C. SAMPLE PREPARATION

For operation using parallel plates, follow Section 10 of AASHTO Designation: TP5. The procedure when using a cup and stepped disc is to pour the heated binder into a sample cup such that the meniscus is above the rim of the cup. Let the cup cool at room temperature for 15 min. Insert the sample cup into a silicone cup holder so that the top of the cup is flush with the top surface of the holder. Heat a clean broad-blade, straight-edge spatula on a hot plate. Trim the excess binder above the top of the cup using the hot blade. The number of repetitions of heating/trimming will vary depending on the stiffness of the binder. Usually two to four repetitions of cleaning/heating/trimming are necessary for one pass. When one complete pass has been accomplished, the surface should be smoothed with a final single stroke pass. Remove the excess binder off of the silicone surface surrounding the cup using tissue. When the holder is clean, push the cup up out of the holder. For asphalt-rubber binders using rubber gradations retained on the 180-µm sieve, only the sample cup procedure is applicable.

This test method is broken into three parts for measurements at different temperature ranges.

PART 1. DETERMINATION OF SHEAR SUSCEPTIBILITY AT 25° C

A. TEST PROCEDURE

The basic procedure is to run a frequency sweep from 1 to 10 rad/s, at 25°C, measuring the complex modulus (G*) and the phase angle Delta (δ). When using parallel plates for this determination, follow Section 11 of AASHTO Designation: TP5, except that data are recorded at frequencies of 1 to 10 rad/s.

When using a cup and plate, install the cup in the sample holder and lower the stepped disc to the point of contact between the 8-mm serrated disc and the sample surface. Zero the vertical distance indicator. Close the environmental chamber. Raise the temperature to 70°C . When 70°C has been reached, lower the 8-mm disc 0.700 mm into the sample. After a 2-min period following the lowering of the disc, reset the temperature for 25°C. When the sample temperature has been at 25 ± 0.1° C for 10 min, run a frequency sweep from 1 to 10 rad/s using the control mode procedures of Sections 11 and 12 of AASHTO Designation: TP5. Record the values of G* and δ at 1 and 10 rad/s.

NOTE: For residues from either the pressure aging vessel (AASHTO Designation: PP1) or the tilt-oven (California Test 374), the 8-mm disc is appropriate. For softer binders, the 25-mm disc may be necessary. Software is available with the rheometers that will control the disc lowering, selection and operational inputs automatically. If a 25-mm plate is used in Part 1, this sample can not be used. Proceed directly to Part 2.

B. CALCULATIONS AND REPORT

There are two shear susceptibility parameters that require calculations from the measured values:

Shear Susceptibility of Viscosity (SSV)

SSV = log (eta* at 10 rad/s) - log (eta* at 1 rad/s)

Where: eta* = complex viscosity = G*/frequency

Shear Susceptibility of Delta (SSD)

SSD = δ at 10 rad/s - δ at 1 rad/s

Report SSV and SSD at 25°C.

PART 2. DETERMINATION OF STIFFNESS AND M-VALUES AT LOW TEMPERATURES

A. TEST PROCEDURE

The basic procedure is to run a frequency sweep from 1 to 100 rad/s at the temperature specified for the grade of binder. Samples that have been tested at 25°C, in Part 1, may be conditioned immediately thereafter by lowering the temperature and maintaining the specification temperature ± 0.1°C for 1 h. For measurements of only the low temperature properties begin with the sample preparation procedure in Part 1, then lower and maintain the specification temperature ± 0.1°C for 1 h.

During the cooling period, the normal mass on the sample is kept at less than 40 g by either adjusting the plate height manually or by using auto tension (if so equipped). A height adjustment is usually necessary for the first 10 min of the cooling period.

If parallel plates are being used, the new spacing is an input to the frequency sweep program along with the test temperature, % strain (start with 0.06 %), logarithmic sweep at 5 points per decade from 1 to 100 rad/s with a 10 cycle correlation delay.

If a sample cup is being used in a Rheometrics RAA, the recommended inputs for the frequency sweep program are as follows: strain constant = 10, stress constant = 18, strain = 0.3 % and the same sweep parameters listed for parallel plates above.

Record the test temperature, G* and frequency.

B. CALCULATIONS AND REPORT

Plot log G*, in Pa, versus log frequency. Determine the m-value as the slope of the curve at 10 rad/s. Report the m-value and Creep Stiffness , where:

Creep Stiffness, in MPa = [3 x G* at 10 rad/s] x 10^{-6}

PART 3. DETERMINATION OF COMPLEX MODULUS AND PHASE ANGLE AT HIGH PAVEMENT TEMPERATURES

A. TEST PROCEDURE

For measurements on standard, polymer modified and asphalt-rubber binders with rubber gradations passing the 180-µm sieve, AASHTO Designation: TP5 for 25-mm plates may be used. For any of the above or asphalt-rubber binders with rubber gradations passing the 180-µm sieve, prepare the sample as described in Part 1 using a sample cup. However, embed the disc 3.1 mm from the zero point which will engage the 25-mm disc. Following a 2-min period after the disc has been embedded, reset the temperature for the specified temperature of interest.

Samples tested in Part 2 using the sample cup may also be reconditioned immediately after the low temperature analysis for Part 3 by raising the temperature to 70°C and embedding the disc to 3.1 mm. Following a 2-min period after embedment, reset the temperature for the specified temperature of interest.

After the sample has been at the set temperature ± 0.1° C for 10 min, run a single point test at 10 rad/s at 12 % strain with a 10 cycle correlation delay. Record the temperature, G* and the phase angle (δ).

B. REPORT

Report G* and the phase angle (δ).

PART 4. SAFETY AND HEALTH

Prior to handling, testing or disposing of any waste materials, testers are required to read: Part A (Section 5.0), Part B (Sections: 5.0, 6.0 and 10.0) and Part C (Section 1.0) of Caltrans Laboratory Safety Manual. Users of this method do so at their own risk.

REFERENCES:

AASHTO Designations: PP1 and TP5
California Test 374

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